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Irrigation Distribution System for Agriculture using Fuzzy Control and Android-Based Water Monitoring

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Abstract—Water is a critical element in agriculture fields. One of them, paddies. In this research developed the smart irrigation system to real-time monitoring that provided the water level information based on Android. The prototype system made using the ultrasonic sensor (HC-SR04) to detect the water level, and the NodeMCU-ESP8266 conducted control system and wireless communication. The fuzzy algorithm provided the Sugeno model in the order. The research achieved RMSE of 0.41, the water monitoring displayed on Android, and reduced time consuming to open gate system

Keywords—fuzzy control, irrigation, monitoring

I. INTRODUCTION

The irrigation system is a method to distribute and manage water resources in agriculture field. That is important to control and monitoring the water distribution for farmer needs. However, water management that useful for water distribution equity. In several method and technology implemented, that influenced to maintain water resource and pollution. Furthermore, it can affect the fertility of the soil compound.

The technology of the digital sensor is utilised and implemented in the agriculture system, it is effective to enhance the harvest quality and environmentally protected [1]-[4]. Some effect of smart technology for irrigation in the agriculture field is water maintaining, soil monitoring, fertiliser controlling, and low-cost development [5]-[7]. On the other hand, the smart system in irrigation technology has provided by using sensing or robotic fields [8]-[12].

By the smart system, irrigation technology can development using real-time control and monitoring. That many products can use long-range communication (e.g., Bluetooth), remotely and Internet-based (i.e., Wireless Sensor Network) [13]-[19]. Besides, to control and monitor of agriculture field that can be obtained through mobile interfaces [20]-[22]. Furthermore, MATLAB Software is applied to analyze system performances [23]-[25].

The aim of this research conducted a smart irrigation system that utilised real-time controlling and monitoring. This research has developed the prototype of the irrigation system. The system has utilised to control and monitoring of the water distribution. By using the digital sensor (i.e., ultrasonic sensor) and the real-time monitoring use Blynk application (android based) that are detected and visualisation of water level. On the system, we conducted fuzzy control using the fuzzy algorithm. This prototype has implemented and tested for the small-gated automation controlling.

II. RESEARCH METHOD

The prototype tested at 24-hours, then informed the gate condition each hour on various water level. In section A explains of membership of the water level conditions (consistently on 0-20 cm) then section B shown the prototype design and section C describes system worked.

A. Fuzzy Control System

The Sugeno model of Fuzzy algorithm applied in this system[26], [27]. To obtain the membership function, it divided water level of t second (absolute measurement) then t-10 second (10 seconds sequentially). Figure 1 shown the membership function that determined by sensor measurement.

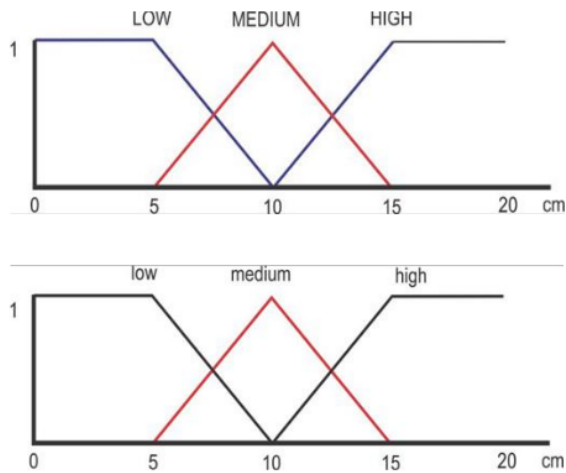


Fig. 1. Membership function of water level (a) t second, (b) t-10 second

The membership function that divided three variable of membership, it showed t second {LOW, MEDIUM, HIGH} then t-10 seconds {low, medium, high} from the water level measurements.

The variable of t second has an equation as follows:

$$\mu_{HIGH}[x] = \begin{cases} x=0; x \leq 0 \parallel x \geq 10 \\ x-10; 0 < x \leq 5 \\ 5-x; 5 < x < 10 \\ 5; x=10; x \geq 15 \end{cases} \quad \mu_{LOW}[x] = \begin{cases} x=0; x \leq 10 \parallel x \geq 20 \\ 10-x; 10 < x \leq 15 \\ 20-x; 15 < x < 20 \\ 5; x=15; x \geq 20 \end{cases}$$

$$\mu_{\text{MEDIUM}}(x) = \begin{cases} x-5 & ; 5 < x \leq 10 \\ 5 & \\ 15-x & ; 10 < x < 15 \\ 5 & \end{cases}$$

(1)

then (t-10) second equation as follows:

$$\begin{aligned} \mu_{\text{HIGH}}(x) &= \begin{cases} x-10 & ; x=0; x \leq 0 \parallel x \geq 10 \\ 5 & ; 0 < x \leq 5 \\ 10-x & ; 5 < x < 10 \\ 5 & \end{cases} \\ \mu_{\text{LOW}}(x) &= \begin{cases} x-10 & ; x=0; x \leq 10 \parallel x \geq 20 \\ 5 & ; 10 < x \leq 15 \\ 20-x & ; 15 < x < 20 \\ 5 & \end{cases} \\ \mu_{\text{MEDIUM}}(x) &= \begin{cases} x-5 & ; x=0; x \leq 5 \parallel x \geq 15 \\ x-5 & ; 5 < x \leq 10 \\ 5 & \\ 15-x & ; 10 < x < 15 \\ 5 & \end{cases} \end{aligned}$$

(2)

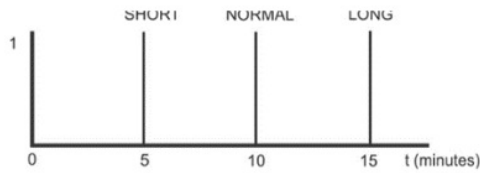


Fig. 2. Membership of time setting

Figure 2 shown the membership of time setting of the irrigation gate system. Those used three variable of minutes (t) {SHORT, NORMAL, LONG}. That explained time consuming to open or closed the gate operation. Table 1 described the fuzzy control rules in the system.

TABLE I. FUZZY RULE SYSTEM			
Water level (t-10s) cm	Actual water level (t) (cm)		
	LOW	MEDIUM	HIGH
low	LONG	NORMAL	SHORT
medium	LONG	NORMAL	SHORT
high	NORMAL	SHORT	OFF

Moreover, to defuzzification proceed, it obtained by the Weighted Average. Eq. 3 is explained defuzzification method.

$$z = \frac{\sum \mu(x) \cdot w_i}{\sum \mu(x) \cdot i} \quad (3)$$

Z = Results of Defuzzification
 μ_x = Min-value
w = Output weight

B. Prototype Design

This research has developed mini gate for irrigation distribution system, the prototype consists by ultrasonic sensor of HC-SR04 module, micro-python of NodeMCU-

Esp8266 module and the DC motor to controlling the gate. In addition, we integrated use wifi communition to real-time data monitoring then show it into Blynk application (Android based) [28]. Figure 3 shown the gate prototype (a) and sensor module (b). The gate system has made 30cm x 60cm.

For testing the system, the gate system is mounted in small paddies field, sensor detected water level, then data transferring into mobile device (smartphone). We provided modem module to facilitate internet connectivity.

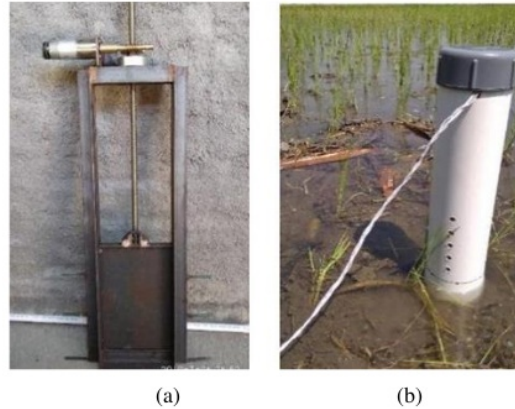


Fig. 3. Prototype design, (a) the mini gate system, (b) sensor mounted

C. Prototype worked

Figure 4 illustrates the flowchart for the monitoring and control system. The control board initially checks the status of the ultrasonic sensor located in the rice field. Then data collected of the ultrasonic sensor will be displayed on the Android application continuously. In every once a day, the motor will be active based on the water conditions in the rice field. If the ultrasonic sensor senses that the water level is the same as or higher than the set-point, the control board does not initiate any decision. The irrigation gate is closed. When the water level is less than the set-point level, the control board sends a signal to the irrigation gate to open and let the water flow from the canal into the rice field. The control board will send a signal to close the irrigation gate when the water level reaches the set-point level.

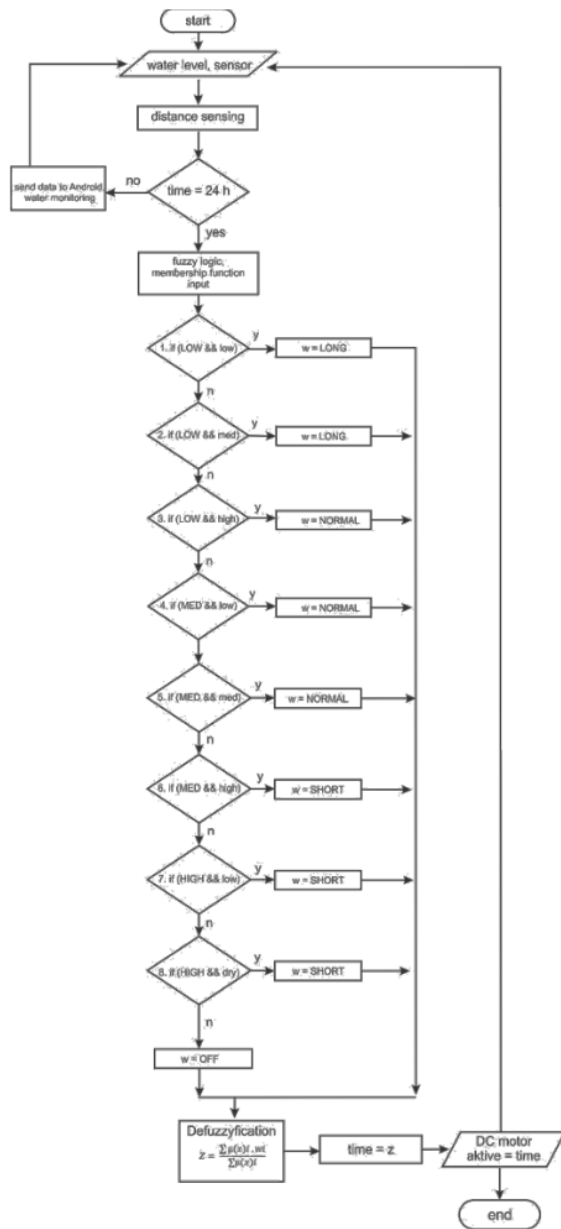


Fig. 4. Flowchart system

III. EXPERIMENTAL AND RESULT

This section has explained data collection then performances compared between absolute measurement and sensor calculation.

A. Experiment Analysis

This research has provided the data acquisition from two method of measurement. We conducted absolute measurement by the measuring instrument and sensor measurement. The data test has used 10 data from acquisition measurement randomly.

TABLE II. DATA MEASUREMENT SYSTEM

Data	Absolute (cm)	Sensor (cm)	Error	Error^2
1	4	4.07	0.07	0.01
2	5	5.17	0.17	0.03
3	6	6.08	0.08	0.01
4	7	7.08	0.08	0.01
5	8	8.42	0.42	0.18
6	9	9.04	0.04	0.00
7	10	10.58	0.58	0.34
8	11	11.32	0.32	0.10
9	12	12.66	0.66	0.44
10	13	13.75	0.75	0.56
Mean			0.32	0.17
Root Mean Square Error (RMSE)			0.41	

Table 2 has obtained error average of 0.32 then RMSE of 0.41. This explained the sensor can utilised for water level detection. To describe the table 2, figure 5 shown chart of data measurement. Water level measurement has visualized in Android based Blynk application on figure 7 comparing B. Gate system performances.

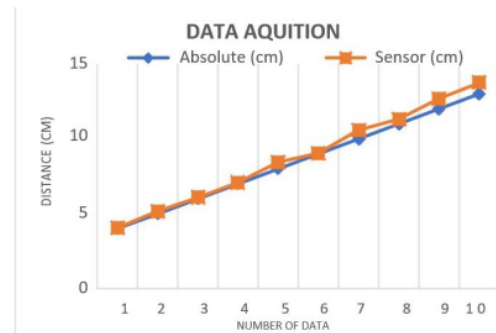


Fig. 5. Measurement

Tabel 3 shown gate rule with describe water level measurement. The gate movement has conduted by time proceed.

TABLE III. RULES OF THE GATE CONTROL SYSTEM

Data	Distance (cm)	Non-fuzzy control (minutes)	Fuzzy control (minutes)
0	0	15	15
1	1	15	15
2	2	15	15
3	3	15	15

4	4	15	15
5	5	15	15
6	6	10	13.57
7	7	10	12.78
8	8	10	12.14
9	9	10	11
10	10	10	9
11	11	5	6.43
12	12	5	5
13	13	5	3.57

Table 3 describes the fuzzy control in the gate system. DC motor controlled automatically by fuzzy measurement. That indicated various time required between two measurement method. We collected in data of 6-9, the fuzzy control shown longer of time proceed compared to simpel control, it happen caused water level condition (water waves).

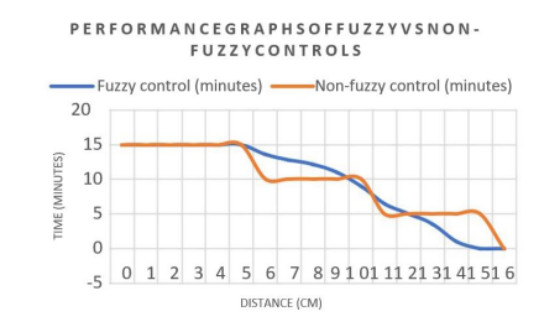


Fig. 6. Performances of gate system

Figure 6 shown achieved fuzzy control system that can be reduced time process of the gate system. That shown fuzzy system that proven better than non-fuzzy system in irrigation system.

After collecting the data, the smartphone displayed the water level condition in hours. Those is used to visualisation of the irrigation management system easily.



Fig. 7. Blynk application

Figure 7 shown real-time monitoring on Blynk application. The application provided display mode including graph, time, water level. These can be updated automatically when connected.

IV. CONCLUSION

We developed the smart system for agriculture through the irrigation distribution system to manage water distribution. These system can be long-time proceed and real-time monitoring using Blynk application. The fuzzy control has involved to optimize the gate system. This research can be applied in agriculture field, and that can farmers and water management officers assisting. In future system development, we will be integrated about more sensors by using WSN architectures.

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